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# **DEVELOPMENT AND USE OF THE OSU ORGANIC FERTILIZER AND COVER CROP CALCULATOR**

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## **ABSTRACT**

Farm advisory visits in Oregon highlighted the need for decision tools to help farmers and agricultural professionals estimate nitrogen (N) mineralization from organic fertilizers and cover crops, design balanced fertilizer plans and identify the most cost effective nutrient management options. Laboratory and field research was conducted to develop N mineralization models for organic fertilizers and compost based on the total percent N. Field methods for estimating cover crop biomass and total percent nitrogen (N) were compared and a preferred method was identified. Cover crop mineralization studies were conducted in the laboratory and field to estimate plant-available nitrogen (PAN) released during decomposition. Two online spreadsheets were developed to compare the cost and benefit of various fertilizer programs, one makes per acre calculations for fertilizers and cover crops, the other makes calculations on a square footage basis for fertilizers only. A website was developed to host the calculator, provide instructions and track users.

## **INTRODUCTION**

Our objective is to facilitate on-farm nutrient management planning that credits cover crop N contributions. To achieve this we validated N mineralization models for organic fertilizers, compost and cover crops using laboratory and field trials (Sullivan, these proceedings). We developed an online spreadsheet that incorporates these mineralization models with economic information. It is designed to be easy to use and to enable rapid, site-specific, accurate and cost effective nutrient management planning that incorporates first year N contributions from cover crops, organic fertilizers and compost.

## **METHODS**

This work began in response to gaps in farmer knowledge that were identified during individual advisory visits with organic growers in 2005-2006. Clients were unable to quickly and reliably develop optimal organic fertilizer programs. Obstacles included the lack of readily available estimates of N mineralization, widely varying nutrient ratios in commonly available organic fertilizers, and an inability to estimate PAN contributions from cover crops. The high cost of organic fertilizer provides a strong incentive for farmers to optimize their fertilizer plans.

In consultation with Sullivan and Andrews, farmers were able to estimate N mineralization from organic fertilizers, but the required calculations were time consuming. Many farmers were confused by the process, and hand calculations proved to be error prone. Some experienced organic growers challenged the high fertilizer application rates recommended when following University fertilizer recommendations. The authors hypothesized that this was due to the fact that

we were not including N contributions from soil organic matter and cover crops, both important N sources on many of these farms. These extension visits inspired development of the OSU Organic Fertilizer and Cover Crop Calculator. The development timeline is described in table 1.

Table 1. Steps taken to develop the OSU Organic Fertilizer and Cover Crop Calculator.

Year	Development Step	Citation
2002-2003	Data collected by Sullivan, Cogger (WSU-Puyallup) and graduate student (Gale) to estimate PAN from a variety of organic fertilizers. The dataset includes 4 site years in the field and lab incubation data for 45 manures, crop residue and compost samples.	Gale et al. 2006
2005	Andrews collects 15 specialty organic fertilizers from Concentrates, Inc. (Portland). Sullivan and McQueen (graduate student) conduct lab mineralization studies to estimate PAN release from these amendments	Sullivan et al. 2010
2006	Andrews, Sullivan and Foster (Oregon Tilth, Inc.) collaborate to develop the OSU Organic Fertilizer Calculator to estimate cost and nutrient value of organic fertilizers and help growers develop the most cost effective nutrient management programs. The calculator was posted online with strong positive response.	Andrews and Foster (2007)
2007-2008	Andrews evaluated simple methods for estimating dry matter, total N and PAN from cover crops in grower's fields. Square quadrat sampling for biomass (lb DM per acre) and lab analysis of biomass (% total N in DM) was determined to be the simplest and most reliable way to estimate crop N uptake. The N mineralization model in the Organic Fertilizer Calculator was used to test whether bulk species samples could also reliably estimate PAN from mixed species cover crops with different N content.	WSARE project report FW06-301
2008-2010	Andrews conducted field trials to measure PAN from cover crops incorporated before summer vegetable crop establishment. Field studies showed that typical N uptake by a mixed cereal/legume cover crop was 60 to 120 lb N per acre (cover crop N concentration 2.0 to 3.5% total N).	Ongoing WSARE project FW09-328
2008-2010	Sullivan and Datta (graduate student) conduct lab incubations to measure cover crop N mineralization. In lab incubation, PAN released from mixed legume/cereal cover crop residue was 30 to 50% of cover crop total N after 70 days in soil at 22°C.	Sullivan et al. (2010)
2010	Andrews, Sullivan, Julian and Pool update the OSU Organic Fertilizer Calculator to include estimates for PAN from cover crops, using published regression equation (Vigil and Kissel, 1991) as the basis for the PAN estimate. The calculator also includes an economic spreadsheet that estimates the cost of managing cover crops.	Andrews et al. (2010)
2011	Sullivan summarizes cover crop lab incubation data for 2008-10.	These proceedings
2012	Andrews and Sullivan revise cover crop prediction equation in Calculator to reflect field and laboratory results obtained (2008-11).	

The online OSU Organic Fertilizer and Cover Crop Calculator (Andrews et al., 2010) was developed to give farmers and agronomists easy access to these research findings and a tool to make site specific nutrient management decisions. The spreadsheet was written using Microsoft Excel version 97-2003<sup>®</sup> in order to make it widely available. On all the worksheets users enter their information in the yellow cells and results are generated in the green cells. Users enter guaranteed analysis and percent dry matter of their amendments in the 'fertilizer analysis' sheet. PAN estimates are expressed as a percent of total N and as lbs PAN per 100 lbs of product on an as-is basis. PAN estimates are provided for 28 days and a full season after application (about 125 calendar days or 2,200 degree days with a 0°C T<sub>base</sub>). When cover crop sampling information and analytical results are entered on the 'cover crop analysis' sheet, cover crop fresh weight, dry weight, total N and PAN are estimated on a lbs/acre basis. The calculator estimates cover crop N mineralization at about 70 days after incorporation. The economic analysis ('your costs') sheet calculates the cost of managing cover crops, including seed, labor, fuel and equipment

depreciation. Time per operation is calculated when users enter their implement width and driving speed using field efficiencies based on American Society of Agricultural Engineers estimates (Hannah, M., 2001). The farm equipment complement is based on Seavert et al., 2007. Straight line equipment depreciation is calculated assuming \$500 per hp value, 20 year life and 200 hour per year use. The ‘cost comparisons’ sheet allows users to compare the cost of nutrients from a variety of fertilizers and the cost of PAN from their cover crops. The ‘nutrients provided’ worksheet allows users to develop fertilizer programs that account for cover crop N contributions and that match fertilizer recommendations.

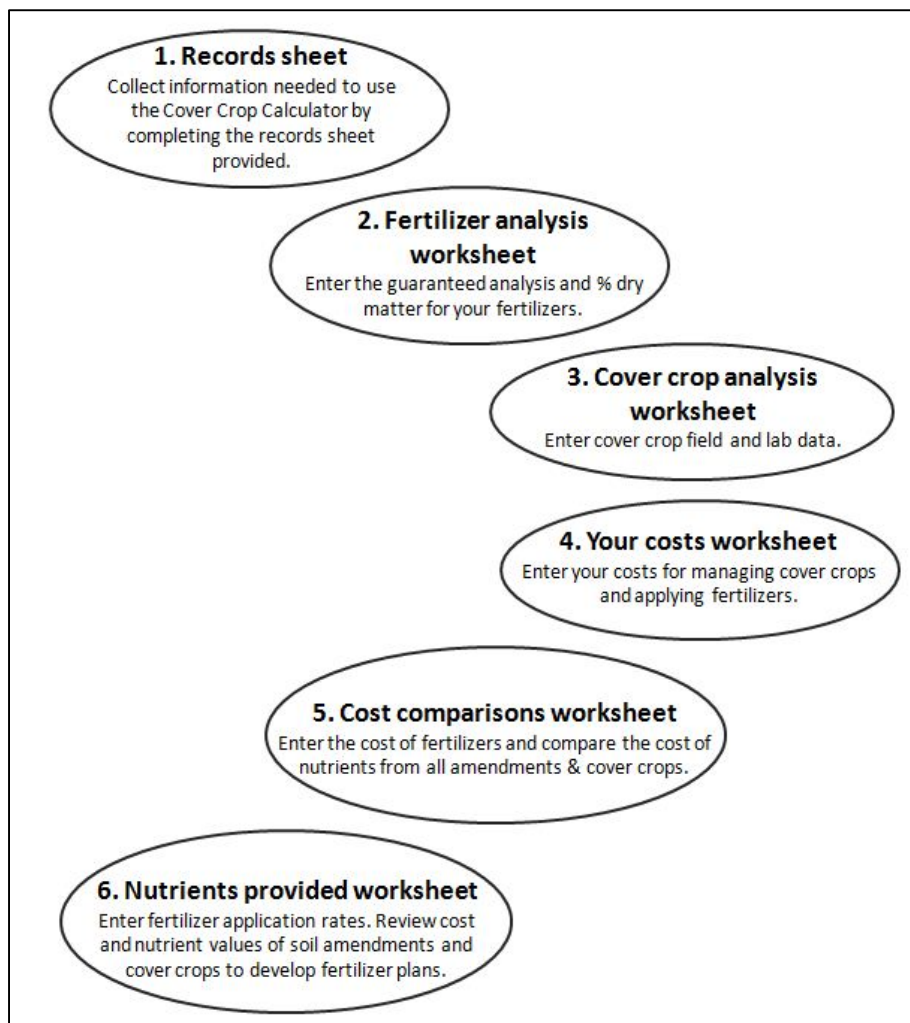


Figure 1. The online quick guide illustrates the major steps in using the calculator.

The website includes a quick step-by-step guide to using the calculator (figure 1). The online ‘records sheet’ helps users collect the information needed to use the calculator. Required nutrient information includes: a fertilizer recommendation, fertilizer analysis, fertilizer percent dry matter, cover crop area sampled, fresh weight of cover crop, percent dry matter of cover crop subsample and cover crop total percent N. In order to compare the cost of various programs the following economic information is needed: fertilizer cost, cover crop seed and inoculant cost, labor cost, fuel cost, tractor size, implement width, and driving speed for various operations.

Before downloading the calculator, users are asked to complete a registration survey. We

ask for their name and contact information, job type, agricultural products they are interested in, and the acreage they manage. Registration information is automatically downloaded to a University database for ongoing impact assessment.

## RESULTS AND DISCUSSION

Realistic but hypothetical scenarios illustrate how the calculator supports site specific nutrient management decisions on farms.

**Scenario 1: Finding the Most Economical Source of a Nutrient as Fertilizer Prices Fluctuate.** Guaranteed analyses and percent dry weight are entered on the ‘fertilizer analysis’ sheet, and the price per lb of each fertilizer is entered on the ‘cost comparisons’ sheet. The bone meal costs \$0.50/lb with a guaranteed analysis of 3-20-0.5, the blended organic fertilizer (8-3-3) costs \$0.55/lb, the chicken manure (3.5-2-2) costs \$0.15/lb, the feather meal (13-0-0) costs \$0.45/lb, and muriate of potash (0-0-60) costs \$0.60/lb. This chicken manure has 65% dry matter, the rest of the amendments have more than 90% dry matter. Among the conventional fertilizers in this scenario, mono-ammonium phosphate (11-52-0) costs \$0.33/lb, triple-super-phosphate (0-45-0) costs \$0.40/lb, and urea (46-0-0) costs \$0.30/lb. Table 2 shows the calculator output. At these prices, the blended organic fertilizer is the most expensive amendment, feather meal is the most economical organic source of PAN, and the chicken manure provides PAN, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O. Bone meal is the cheapest organic source of P<sub>2</sub>O<sub>5</sub> and muriate of potash is the cheapest source of K<sub>2</sub>O. All of the conventional fertilizers are considerably cheaper than organic fertilizers. The ‘costs comparisons’ sheet attributes the full cost of a fertilizer to each individual nutrient. So a product supplying more than one nutrient may not be the most economical source of any one nutrient, but may be part of the most economical fertilizer program depending on the fertilizer recommendation (see scenarios 3 and 4).

Table 2. Cost comparisons of organic and conventional fertilizers at hypothetical prices.

Organic Fertilizer	Full season PAN (% of total N)	Full season PAN (\$/lb)	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
Bone meal (3-20-0.5)	32%	\$51.49	\$2.50	\$100.00
Blended organic fertilizer (8-3-3)	75%	\$9.17	\$18.33	\$18.33
Chicken manure (3.5-2-2)	66%	\$6.52	\$7.50	\$7.50
Feather meal (13-0-0)	75%	\$4.62	-	-
Muriate of potash (0-0-60)	-	-	-	\$1.00
<b>Conventional fertilizer</b>				
Mono-ammonium phosphate (11-52-0)	100%	\$2.95	\$0.63	-
Triple-super-phosphate (0-45-0)	-	-	\$0.89	-
Urea (46-0-0) (not organic)	100%	\$0.65	-	-

**Scenario 2: Estimating Cover Crop PAN and Comparing the Cost of Cover Crop and Fertilizer PAN.** A field is cover cropped with a mixture of cereal rye and common vetch. Just before incorporation, four 2ft x 2ft quadrats are sampled, total area sampled is 16ft<sup>2</sup>. We recommend 4-5 quadrats for most reasonably even cover crop stands. The total fresh weight of this field sample is 8lbs, total percent N and dry matter from laboratory analysis are 3.0% and 22% respectively. The calculator estimates that this cover crop provides 4,792 lbs/acre dry matter, 144 lbs/acre of total N and 57 lbs/acre of PAN. Cereal rye cost \$0.30/lb and was seeded at 30 lb/acre, common vetch seed cost \$0.70/lb and was seeded at 60 lbs/acre, inoculant cost

\$2.00/acre. A 70 hp tractor is operated at 4mph for all field operations. The cover crop is seeded with a 12' drill and irrigated once after seeding. In the spring it is flailed once with an 8' flail mower and disced twice in addition to normal tillage operations with a 12' disc. Fertilizers are broadcast with the same tractor and a spin spreader with a 20' broadcast width. If all cover crop management costs are attributed to available N, cover crop PAN costs \$1.90/lb, and is a more economical N source than the organic fertilizers in scenario 1. If a farmer is already using a cereal cover crop to protect soil over the winter, it is reasonable to attribute only the cost of legume seed and inoculant to cover crop PAN. In this comparison, cover crop PAN costs \$0.77/lb, and is only slightly more expensive than urea in scenario 1 as a source of PAN.

**Scenario 3: Developing a Cost Effective Organic Fertilizer Program without Cover Crops.**

If a fertilizer recommendation calls for 100lbs/acre of PAN, and 50lbs/acre of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O, a farmer may want to compare different fertilizer programs to find the most balanced and cost effective option. Three options are compared: 1) chicken manure; 2) chicken manure supplemented with feather meal; and 3) a blend of feather meal, bone meal and muriate of potash. The calculator generates cost comparisons that can include the cost of application, as shown in table 3.

Table 3. Comparison of the cost and nutrient value of three organic fertilizer programs.

Fertilizer program	Application rates (lbs/acre)	Nutrients provided (lbs/acre N-P-K)	Program cost (\$/acre)
Chicken manure	4500	104 – 90 – 90	\$677.60
Chicken manure / feather meal	2500 – 450	101 – 50 – 50	\$580.10
Feather meal / bone meal / muriate of potash	1050 – 250 – 85	105 – 50 – 52	\$651.10

**Scenario 4: Developing a Cost Effective Organic Fertilizer Program with Cover Crops.**

This fertilizer recommendation is also 100-50-50, but credits the cover crop N contribution from scenario 2 (57 lbs PAN/acre). In this example, when cover crop PAN contributions are included in the fertilizer plan, chicken manure provides approximately the desired ratio of N-P-K without a supplemental high nitrogen fertilizer (table 4), and is very similar in cost to the feather meal, bone meal, muriate of potash program.

Table 4. Cost and nutrient comparisons of two organic fertilizer programs attributing all cover crop management costs to cover crop PAN and attributing the cost of legume seed and inoculant to the cost of cover crop PAN.

Fertilizer program	Application rates (lbs/acre)	Nutrients provided (lbs/acre N-P-K)	All program costs (\$/acre)	Fertilizer, seed and inoculant only (\$/acre)
Chicken manure	2500	114 – 50 – 50	\$493.59	\$429.47
Feather meal / bone meal / muriate of potash	450 – 250 – 85	103 – 50 – 52	\$497.09	\$432.97

These scenarios illustrate some benefits of using the calculator to include cover crop PAN contributions in fertilizer plans, and to determine the most balanced and economical supplemental fertilizer programs. Potential savings from including cover crop N in fertilizer plans are in excess of \$100/acre depending on the standard grower practice used for comparison.

The original OSU Organic Fertilizer Calculator was updated to include cover crops in May 2010. At that time, the Organic Fertilizer Calculator had been downloaded more than 4,800 times and had over 1,300 registered users from 64 countries representing every continent. Of the users, 1040 are in the US, representing all 50 states. There were 344 registered users in Oregon, 165 in Washington and 107 in California. Survey respondents selected from acreage categories with >50 acres being the largest farm option, we estimated that more than 45,000 acres were managed by registered users.

The survey was updated when the OSU Organic Fertilizer and Cover Crop Calculator was launched so that larger farms could be accounted for. 7 months after launch, the new calculator has about 240 registered users who manage over 33,000 acres. Average farm size of registered users is about 220 acres. Of these early adopters, about 170 are agricultural professionals. We conducted an informal e-mail survey of agricultural professionals registered to use the calculator, 19 completed the survey. Of these, 8 use it in their teaching, 11 use it in extension work, 7 use it in their research, and 4 do not use it but are interested in doing so. The calculator was rated as very useful, 4.4/5. Respondents like the ease of use, and report that it provides information not readily available elsewhere. They also appreciated that estimates are based on research findings rather than broad estimates. Some felt that the interface could be more user friendly, especially for farmers not familiar with Excel. Others expressed concern that mineralization rates might not be consistent in all environments, and were interested in more detailed information on the timing of PAN release from cover crops.

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